SYNOPSIS

The thesis entitled "**Study of Deccan trap flows in Chikhaldara Ghat Section (Dist. Amravati)"** is divided into six Chapters and brief summary of each chapter is given below

CHAPTER NO. I

INTRODUCTION

Deccan Trap is major Geological formation covering about 82% of the area of Maharashtra state. Until recently it was believed that the Deccan Plateau is a product of Fissure type of volcanic eruption having monotonous uniformity in petrological and structural characters, however after independence the geological investigations made at different Engineering sites and for ground water exploration revealed that there is considerable variation in the field characters of Basalt flows. Such variation in the field characteristics led to further studies which were mainly confined to geochemical aspects of Basalt Flows.

The literature survey shows that various Geoscientists carried out geological studies of Deccan Trap Basalts of Maharashtra, Malwa Plateau, Taptee and Narmada valley etc.

Various papers published in International journals and papers presented at symposium on Deccan Trap have covered various aspects of Deccan Trap formation that include petrochemistry, paleomagnetic studies, and Tectonic aspects of Deccan Trap. However in these works a little attempt has been made to decipher nature of volcanicity that has produced basalt flows in time and space. The Deccan Trap was always considered as product of Fissure type of eruption but it was for the first time Agashe and Gupte (1968, 1971) have shown that in addition to fissure type, central type of volcanicity also existed in some part of Deccan Trap.

Area of Research Work:-The area selected for determination of nature of volcanic activity is Chikhaldara Ghat section situated at a distance of 100 km from Amravati city accessible through road from Achalpur. Basalt flows are exposed along the ghat section in the vertical cuts along this approach road from R.L.600m to R.L 1092m. From the detailed study of field characters of Basalt Flows, their petrographic and chemical studies, an attempt has been made to throw light upon the nature of volcanicity of the area.

CHAPTER II

GHAT TRAVERSE

The traverse was taken from Km.stone, 19km Achalpur, (R.L. 600m) up to Chikhaldara Hill Station km stone,33.6km Achalpur (R.L. 1092m).The Basalt flows exposed along this stretch were demarcated and serially numbered from flow no. 1 to Flow No.16 with the help of critical studies of field characters of these flows.

For demarcation of different Basalt Flows following criteria has been used.

1. Petrological Difference: -Petro logical difference between top portion of underlying flow and bottom portion of overlying flow

2. Occurrence of Red boles, Black boles and Green boles along junction of two flows: - With the help of occurrence of Red boles, Green boles, and Black bole occurring in between two consecutive flows at many places, the flows could be easily demarcated.

3. Difference in appearance of outcrops: - With the help of difference in appearance of out crops top portion of underlying and bottom portion of overlying flows could be determined.

4. **Difference in the appearance of joint blocks**: - Joint blocks of Compact Aphanitic Basalts have smooth appearance, where as that of Compact Porphyritic Basalts are having pitted and rugged appearance. Due to this difference in appearance two flows could be demarcated.

A compound flow of Amygdaloidal basalt consists of 14 units of thin and thick irregular flows. These thin and thick irregular flows have also been demarcated from each other with the help of ropy structure at the top and occurrence of pipe amygdales at the bottom of individual flows of amygdaloidal basalts.

In the Ghat section out of 16 flows, one flow is compound flow (Flow No.2) i.e. thin and thicker piles of Amygdaloidal Basalt flows, 14 flows are of Compact Basalt (7 flows are of Compact Porphyritic Basalt and 7 are of Compact Aphanitic Basalt) and one flow is of Volcanic Breccia.There is one band of Black bole, two bands of green boles, and two of Red boles separating different flows from each other. Their detailed characters useful in determining nature of volcanicity have been described in this chapter.

CHAPTER III

FIELD CHARACTERS OF DECCAN TRAP BASALT FLOWS

Field Characters of Basalt Flows in Chikhaldara ghat section show that there are following 4 types of Basalt flows occurring in the ghat section between R.L. 600m to R.L. 1092m

1. Thick extensive flows of Compact Aphanitic Basalts
2. Thick extensive flows of Compact Porphyritic Basalts
3. Compound flow of Amygdaloidal basalt (Piles of thin and thicker irregular flows)
4. Bands of Black, Green and Red boles

In the vertical stretch of 492m which has been thoroughly studied, Compact Aphanitic and Compact Porphyritic Basalt flows make up 447m (91%) of the thickness. In remaining vertical stretch only 30m (6%) is occupied by Amygdaloidal Basalt i.e. Compound flow and 15m (3%) is occupied by Volcanic Breccia.

The concise account of Field Characters of Basalt flows:-On the basis of Lithological Characteristics, the basalt flows have been grouped in to Compact Porphyritic Basalts and Compact Aphanitic Basalts. As mentioned in Chapter II, 7 flows are of Compact Aphanitic Basalts making 250m thickness (51%) and remaining 7 are of Compact Porphyritic Basalts having 197m thick stretch (40%). The remaining 9% stretch is occupied collectively by Amygdaloidal Basalt and Volcanic Breccia.

Variation in Thickness of Compact Basalt Flows: - On the basis of thicknesses measured in the field it is observed that thickness of Compact Basalt flow varies from 12m to 47m. Maximum and minimum thickness of Compact Porphyritic Basalt is 47m and 23m respectively, where as Maximum and minimum thicknesses of Compact aphanitic Basalt are 40m and 12m respectively. Variation in their characters such as thickness, texture, lithology, nature of joints with minute details has been described in this chapter.

CHAPTER IV

PETROGRAPHY OF BASALT FLOWS

This Chapter deals with Petrographic characters of the Basalt Flows occurring in the area.

Mineralogy of Basalt Flows:-

The Basalt flows consist of large quantity of Plagioclase, Pyroxene with subordinate quantity of altered olivine embedded in glassy or microlitic ground mass. Proportion of these minerals by volume has been determined by Delesess-Rosiwaal method.

Description of Major and Large sized Minerals:-

Major minerals like Plagioclase,Pyroxene,Olivine, Iron Ore have been described in terms of volume,Alteration,Corroded borders,Inclusions,Twinning,zoning,

Plagioclase: - Plagioclase is occurring in two generations i.e. First and Second generation.

Volume: - Plagioclase is the prominent and large sized mineral occurring in Basalt flows. The phenocrysts are sometimes slightly altered and show corroded borders. Some show inclusions of anhedral pyroxenes. 'An' content of plagioclase has also been determined.

Pyroxene: - Only Clino pyroxene occurs in all the Basalt flows of the area. It is non pleochroic and its occupied volume is 20.18%. Pyroxene occurs as granules or rarely euhedral and subhedral crystals. Occasionally elongated slender prisms of augite are seen. Augite phenocrysts are much smaller in size than plagioclase phenocrysts.

Olivine: - Small to medium sized with anhedral rounded granules mainly restricted to ground mass are seen in theflows. It is found to be altered to iddingsite, serpentine and iron ore.

Inclusion:- Inclusion of olivine in plagioclase phenocryst and also in pyroxene are found in few flows. Flows of this area also show development of magnetic iron ore around olivine granules and along cracks.

Iron Ores: - The Iron ores occur as plates, rods, granules, needles and dust. They also occur as microlites and crystallites in the glass and gives black colour to it. Proportion of Iron ore is different in different types of flows.

TEXTURES

Microscopic study of thin sections of various Basalt flows of this region has shown that these flows consist of following textures.

Porphyritic, Glomeroporphyritic, Intergranular, Intersertal, Ophitic, Subophitic, FlowTextures, Vesicular and Amygdaloidal which are noted and discussed in this chapter.

CHAPTER V

PETROCHEMISTRY OF BASALT FLOWS

INTRODUCTION

The work of Chemical analysis has been carried out to determine nature of magma type of the flows occurring in the Chikhaldara ghat section. With the help of Chemical analysis an attempt has been made to find out distribution of Major elements, Trace elements and Rare Earth Elements in the Basalt flows of Type F2 and F3.

Previous Geochemical work on Deccan Trap

Geochemical work on Deccan Trap has been carried out by Vemben (1947), Sukeshwala and Poldervaart (1958), West (1958) and Chatterjee (1964), Karkare (1965), etc. Large numbers of papers have been published on Geochemistry section in a special issue of Bulletin Vulcanologique.

Samples studied:-

Sixteen samples of the flows from flow no.1 to 16 have been analyzed chemically. Out of these 16 samples 7 samples are of Compact Porphyritic Basalt and 7 are of Compact Aphanitic Basalts. One flow is of Amygdaloidal basalt (compound flow) and one is of Volcanic Breccia.The average composition of these flows have been worked out and compared with average composition of Deccan trap Tholeiites and Olivine Basalts.

Variations in the major oxides, Trace and Rare Earth Elements in the flows of type F2 and F3 have been studied.

Determination of nature of Magma type:-

The chemical analysis has been carried out to determine nature of magma type of the rocks studied. The methods used have been divided into following four groups.

1. Methods based on Crystallization Parameters
2. Methods based on plotting of various oxides
3. Classification Based on CIPW norms.
4. Classification Following Chemical definitions

1. Methods based on Crystallization Parameters:-Various crystallization parameters which have been proposed in order to draw proper results about cooling history of basaltic magma are as below

i) Felsic index ii) Mafic Index iii) Plots of Felsic index against mafic index iv) Classification by Poldervaart

Solidification Index: -Solidification Index proposed by Kuno (1959) has been used for classification of rocks of the area studied.

2.Methods based on plotting of various oxides:- As per Sinha(1972,p.1045) the ratios FeO:MgO,SiO_2:MgO,Fe_2O_3:FeO and Felsic:Mafic point towards Geochemical differentiation in large scale. However here differentiation is related with changes in composition of magma which leads to difference in behavior of the oxide ratios and index of differentiation. With this view various oxides have been plotted against each other as given below.

i) Plots of total alkalis against SiO_2 ii) Total Alkalis against Al_2O_3 iii) Kuno's classification of Basalts based on total Fe_2O_3 iv) Plots of MgO against Al_2O_3/SiO_2 v) Plotting of MgO against FeO + Fe_2O_3 vi)F.A.M Triangular diagram vii) S.K.M. Triangular diagram viii)Ca-Na-K Triangular diagram ix) Rittman's "P" value x) Ritmanns suite index xi) Sugimures θ value xii)Sugimures S.W.S. index xiii) Oxidation Index

3. Methods based on CIPW norms

a) f norm of Barth:- f norms have been calculated for rocks of this area . There is general acceptance that feldspar started crystallization earlier than pyroxene during cooling of magma of Deccan Trap region.

b) Kunos classification based on colour index:-

On the basis of colour index excluding phenocrysts Kuno classified rocks i.e. by the sum of normative femic minerals. The rocks having colour index greater than 37 are considered as basalts

c) Crystallization index:-Poldervaart and Parker proposed parameter C.I. which measures progression of partial magmas or igneous rocks, from primitive system an-di-fo. C.I. is expressed in wt. Percentage and is defined as C.I. = (An + Di + Fo + Sp). The C.I. is calculated after norm is recalculated to 100%

d) Poldervaarts A value:-Poldervaart classified Basaltic rocks carrying both olivine and hypersthene in norm in to tholeiite and Alkali Basalt according to equation Ab-1.96 x Enhy-1.49Fshy=A. If A is positive analysis is of Alkali Basalt and if A is negative the analysis is of Tholeiite.

4) Classification Following Chemical definitions:-

a) Yodar and Tilleys Classification

b) Macdonald and Katsura's Classification

Magma Types: - Various terms have been used to determine magma type since earlier days. The Deccan Trap magma is considered as representative of Tholeiitic magma type.

Conclusions:-

As have already been stated main aim of petrochemical study was to determine nature of magma type of the rocks of the area studied, i.e. Chikhaldara ghat section. The attempt has been made to describe type of magma with the help of various diagrams and calculation methods which have already been described.

Following is list of methods which were used

1. Methods based on crystallization parameters
2. Methods based on plotting of oxides
3. Classification on the basis of CIPW norms.

CHAPTER VI

Nature of Volcanic Activity

On the basis of field characters of Basalt Flows the attempts have been made to determine nature of volcanicity that was prevailing in time and space in western and central parts of Maharashtra state. However such studies are yet to be made on similar lines to determine nature of volcanicity of the area. As field characters of Basalt flows provide clues to the nature of volcanicity, detailed studies of field characters of Basalt flows exposed in Chikhaldara ghat section were carried out, where thick piles of Basalt Flows are exposed in road cuts, in the vertical stretch of 492m. (R.L. 600m to R.L 1092m.)

All these Basalt flows have been studied in detail,as they provide clue to the nature of volcanic activity that produced them. As Lava flows are formed by solidification of liquid, the relationship between lateral extent and thickness depends upon fluidity of lava. Therefore if lava is fluid enough to flow freely its top surface will be plane and horizontal, on the other hand if the lava is viscous the top surface will be irregular, bulbous in form with less L/T ratio. These observations are useful in determining nature of Deccan Trap volcanicity.

Thickness, Lateral extent and L / T Ratio

From the detailed study of Field Characters of Basalt flows in the study area it is observed that there is a lot of variation in thickness and lateral extent of Basalt flows. Most of the flows are of Compact Basalt having extensive lateral extent with high L/T ratio. Also few flows of amygdaloidal Basalts (Compound Flows) having limited lateral extent and low L/T ratio are occurring in this area. It is clear from extensive flows of Compact Basalts with high L/T ratio that these flows have been resulted from fluid lava extruded in a very large quantity, where

as limited lateral extent with low L/T ratio of Compound Flows indicate that they must have been formed from small quantities of viscous lava. Such a variation in thickness and lateral extent indicates that different types of volcanic activities had given rise to different types of Basalt Flows.

When morphology of different types of flows is taken into consideration then it is confirmed that there was significant difference in fluidity of lavas which after consolidation resulted into different types of flows, and thus also indicates possibility of different type of volcanicity.

MORPHOLOGY OF BASALT FLOWS

COMPACT BASALT FLOWS:-

Morphology of Compact Basalt Flows:-

Thick extensive flows of Compact Basalts studied in this region are having regular tabular form. Their tops as a whole are plane surfaces. These flows are having considerable lateral extent and are traceable for longer distances. As compare to lateral extent they are small in thickness. (Max.47m and min.12m)

The extensive lateral spread ,large thickness , high L/T ratio and absence of vesicularity except in the top portions of individual flows indicate that the Compact Basalts are product of Fissure type of Volcanicity characterized by floods of enormous quantities of fluid Basaltic lavas that spread over a few hundred square Km. as thick horizontal sheets.

Predominance of Compact Basalt Flows:-

In the vertical stretch of 492m of Chikhaldara ghat section Compact Basalts are occurring in the form of Tabular flows and Amygdaloidal Basalts are occurring in the form of undulated flows. Also Black, Green and Red boles are occurring in the form of bands. Out of total stretch of 492m.Compact Basalt in the Ghat section is having vertical thickness of 447m., where as Compound flows of Amygdaloidal Basalts are having comparatively very lesser thickness of only 30m

Origin of Compact Basalt Flows:-

Thick and Extensive flows of Compact Basalts having high L/T ratio occurring in Chikhaldara Ghat section are indicative of Fissure type of Volcanicity.Thus floods of enormous quantities of Basaltic Lavas have spread over few hundred square km,giving rise to thick horizontal sheets of Basalts. This shows that in the area above R.L. 600m up to R.L. 1092m i.e. top of Chikhaldara hill station fissure type of volcanicity was predominant.

Amygdaloidal Basalt Flows:-

Morphology of Amygdaloidal Basalt flows is different from that of Compact Basalt flows. Therefore it goes to show these flows are not product of fissure type of eruption.The undulated, irregular form of these flows within limited lateral extent and low L/T ratio indicates that these flows must have been formed from less quantity of viscous lava. Similarly viscous lava must have been outpoured through large no. of outlets. This type of volcanic activity was very insignificant in North East part of Maharashtra as Amygdaloidal Basalt flows are occurring within narrow stretch of 30m i.e. between R.L. 647m to R.L. 677m. In addition to these flows there are Volcanic Breccias, Bands of Black, Green and Red boles.

LATERAL EXTENT OF THE TYPE OF VOLCANICITY

To determine lateral extent of type of volcanicity that was prevailing in Chikhaldara Ghat section, Basalt flows occurring at the same elevations in the North West area i.e. in Toranmal and Ajanta Ghat sections are taken into considerations (Tejankar A.V.2002). The Toranmal Ghat is located at a distance of 283.416 km towards N 80^{o}W of Chikhaldara. , Where as Ajanta ghat is located at a distance of 181.232 km towards S 57^{o}W of Chikhaldara. The flows of Basalt exposed at same R.Ls in Chikhaldara and Toranmal have been compared, from which it is clear that major bulk of these ghat sections are of Compact Basalts, indicating prevalence of Fissure type of Volcanic Activity. The occurrence of Amygdaloidal Basalt Flows, making up only 6% indicates, along with fissure type there was different type of activity in lesser extent was active in which small quantity of viscous lava outpoured at a time from a large number of small outlets occurring in groups with overlapping areas of influence, as shown by Karmarkar (1974) and Kulkarni P.S. (1984).This comparison shows that in North East and North West part of Deccan Trap area above R.L. 600m Fissure type of activity was prevalent. For comparison of Nature of Volcanic activity in Central part of Deccan Trap Mhaismal Hill Station is available. In this Ghat Section which is located towards S 56^{o}W of Chikhaldara at a distance of 244.856km, it is observed that here also fissure type of activity was prevalent above R.L. 767m. This comparison of Basalt Flows also holds true for Sinhagad Ghat Section above R.L. 920m.

Chemical Analysis:-

The Chemical analyses of 15 basalt flows have been compared with those of Basalt flows exposed in Toranmal Ghat Section and have been, thus, discussed in this chapter.

Vertical variation in nature of Volcanicity in Deccan Trap area:-

As can be seen from above observations, in Chikhaldara ghat section which is located towards North East of Deccan plateau, Thick extensive flows of Compact Basalt representing Fissure type of volcanic activity are occurring above R.L.600m up to R.L. 1092m,i.e. Chikhaldara Hill station. In the same way along southern part of Deccan Trap the Compact Basalt flows are occurring between R.L. 625m and R.L.1215m.In Marathwada region which particularly represents central part of Deccan Trap the flows of Compact Basalt are predominantly occurring above R.L.710m.(Marathe et.al.1980,Kulkarni P.S.1984)

It is interesting to see that in all these areas of Deccan Trap the flows of compact basalt representing Fissure type of volcanicity are predominantly occurring at higher levels, whereas the thin flows of amygdaloidal basalt representing quite different type of volcanicity are occupying lower portions almost up to sea level.